What do people want? An analysis of citizens' willingness to use Advanced Air Mobility in Italy

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Abstract

This paper investigates the drivers of citizens' willingness to use Advanced Air Mobility (AAM) systems. We focus on individual and regional features and analyse Italian data on these features through a multinomial logit specification. Our results show that individuals' job positions, flying habits, and prior experience with drones positively influence such willingness. We also find that regional factors matter, with respondents living in poorly-connected and less innovative regions being more willing than others to use AAM.

Keywords: Advanced Air Mobility; willingness to use; individual and regional features; Italy.

JEL codes: R41; O33; O18.

1. Introduction

Advanced Air Mobility (AAM) is "*a new, safe, secure, and more sustainable air transportation system for passengers and cargo* [...], *enabled by new technologies and integrated into multimodal transportation systems*" (EASA, 2021)[1]. In this paper, we focus on autonomous uncrewed aircrafts (*e.g.*, vertical take-off and landing drones with no pilots on board) as an allegedly promising transportation mode for people relying on emerging technologies[2].

The literature on socio-technical systems predicts that contextual economic environments and institutions shape the development, adoption, and diffusion of technologies (Geels, 2004). Accordingly, AAM is fated to cause changes both in transportation modes and in citizens' habits.

Some pioneering studies investigated citizens' social acceptance of AAM (for a recent review, see Straubinger et al., 2020). Specifically, scholars and practitioners associated citizens' actual willingness to use AAM with socio-demographic features (*e.g.*, education and gender), operational performance, and drone-related concerns (*e.g.*, service efficiency and reliability, see Al Haddad et al., 2020).

Building on this emerging literature, we put forward the following research question: *are citizens willing to use AAM and what factors make them more or less inclined to use it?* We advance extant knowledge in two directions. First, we add to prior works by considering a broader set of individual features, encompassing people's flying habits and attitudes towards (small) drones. Second, we investigate whether the citizens' willingness to use AAM depends

[1] Advanced Air Mobility extends the concept of Urban Air Mobility, including private, long-range, and thin-haul flights (Federal Aviation Administration, 2022, accessed October 10th 2022: www.faa.gov/uas/advanced_operations/urban_air_mobility).
[2] The first commercial operations in European cities are expected in 2025 (EASA, 2021).

also on the characteristics of the geographical areas where they reside (*hereafter*: *regional features*), such as the local firms' level of innovativeness or the mobility-related features.

2. Data and method

The dependent variable, *Willingness*, is a categorical variable with three outcomes: the respondent is keen on using AAM systems (*Yes*); she is, but only out of necessity (*Necessity*); she is not willing to (*No*, this last category is the baseline). We estimate the following multinomial logit model, specified as[3]:

$$Willingness_{ij} = \alpha_{ij}^{0} + Individual_i\beta_j + Region_i\gamma_j + Controls_i\delta_j + \varepsilon_{ij}$$

where j $(1, 2, 3)$ indicates the outcome and i $(1, \dots, n)$ indicates the respondent. We consider two sets of focal variables: *Individual* includes variables capturing citizens' individual features, while *Region* encompasses variables referring to the features of the regions where individuals reside. *Controls* group other variables, which we deem relevant to the phenomenon under investigation. Standard errors are clustered at the regional level[4]. We further assess this relation by calculating average marginal effects (AMEs, Williams, 2012). AMEs allow us to estimate whether the considered variables affect each outcome and to meaningfully interpret the magnitude of these effects (Hoetker, 2007).

To set up the database of this study, we leveraged the data collected in collaboration with the *"Drones and Advanced Aerial Mobility Observatory"*[5] of Politecnico di Milano through an online survey administered between November and December 2021 to a stratified random sample of 3,422 Italian citizens aged 18-74; 1,056 responses were collected (response rate: 30.86%). After data cleaning, we obtain a final sample of 1,007 respondents, which (closely)

[3] For a punctual examination of multinomial logit models please refer to Greene (2008, p. 763).
[4] Considering the hierarchical nature of the variables, we estimate a generalised structural equation model as a robustness check (Skrondal and Rabe-Hesketh, 2003).
[5] https://www.osservatori.net/it/ricerche/osservatori-attivi/droni-e-mobilita-aerea-avanzata, accessed October 10th 2022.

matches the Italian population in terms of age, gender, and region of residency (see Table A1, Appendix 1).

From the survey, we got the *Individual* covariates. We consider *Age* (in years), gender (1 for *Female* respondents and 0 otherwise), level of education, and job position. Specifically, we identify *Graduates* (with at least a bachelor's degree), and respondents appointed to *Executive* or *Non-executive* positions (the category of people not currently attached to the labour force is the baseline). We also look at whether respondents were *Moderate* (up to three flights/year) and *Frequent flyers* (more than three flights/year) before Covid-19, keeping those who never flew as baseline. Moreover, we assess respondents' *Prior drone experience* considering whether they have ever used drones before, and the number of drone applications they know (*Known drone applications*)[6].

We combine these individual-level data with *regional features* retrieved from the Italian Statistical Office (ISTAT). Given the industrial and policy goal of creating an innovative and sustainable transportation system through AAM, we assess the regional levels of innovativeness, transportation services, and related pollution. Accordingly, we include the regional *R&D share of GDP*, the share of firms introducing product and/or process innovations (*Share of innovators*[7]), the use of *Public transportation*, and the *CO2 emissions* in equivalent tonnes from road transportation[8]. These variables are averaged over the 2017-2019 years, covering the pre-Covid period. Table 1 reports their descriptive statistics.

[Table 1 about here]

[6] We considered the following drone applications: substance dispensing; warehouse inventory; inspections and surveys; search and rescue; security and surveillance; entertainment; transport of goods; transport of biomedical products; transport of people; maintenance.
[7] This variable is retrieved from the Italian Community Innovation Survey (CIS) taken in 2018.
[8] We measure the level of utilization of *public transportation* as the natural logarithm of the number of people moving with public transportation over the total number of movers, and *CO2 emissions* as the natural logarithm of the number of equivalent tonnes emitted (in thousands).

Finally, we add a further set of control variables[9]. We control for *Urbanisation* by including the population density of municipalities, whether they are farther than 20 kilometres from the Provincial capital, and the share of municipal *Mountainous* territory (more than 600 meters above the sea). We then account for the *Relative wealth* of each province using the quality-of-life index of Il Sole 24 Ore for 2019[10]. Finally, we include the five macro-area dummies as defined by ISTAT (*North-East, North-West, Centre, South,* and *Islands*).

3. Results and discussion

Table 2 reports the coefficients (*No* is the baseline) and Table 3 the average marginal effects of the multinomial logit model. When commenting AMEs, we target the *Yes* category. The use of AAM out of necessity is mostly unexplained (AMEs are not significant, and most coefficients are not robust); we interpret it as being primarily circumstantial. Regarding individual features, women are 7.4% less willing to use AAM; the same holds for older people (-0.2% when age increases by one year). We attribute this phenomenon to the well-documented risk-aversion of these two groups of people (Croson and Gneezy, 2009). Education is non-significant. Instead, being attached to the workforce does matter. In particular, holding an *Executive* role increases the probability of being keen on using AAM by 16.0%, while having a *Non-executive* position increases it by 7.9%. Previous flying habits are relevant; being a *Frequent flyer* increases the probability above by 14.0%. As to familiarity with drones, we note that having *Prior drone experience* makes citizens more willing to use AMM, with a magnitude of 14.2%.

Results on regional features are nuanced. The use of *Public transportation* strongly decreases (by around 20%) the probability of being keen on using AAM. Conversely, *CO2 emissions* decreases the one of being not keen on using it. As to innovativeness, the *R&D share of GDP*

[9] For the sake of brevity, we did not include these control variables in the tables. Results are available from the authors upon request.
[10] Source: https://lab24.ilsole24ore.com/qualita-della-vita-2019/classifiche-complete.php, accessed October 10th 2022.

has no effect, while the *Share of innovators* slightly and negatively affects the willingness to use AAM (AME -2%). Of note, all results but CO2 emissions are confirmed by the robustness check (Table A2, Appendix 2).

[Tables 2 and 3 about here]

4. Conclusions

This paper adds to the literature on AAM by studying citizens' willingness to use it (Al Haddad et al., 2020; Straubinger et al., 2020). In particular, it assesses which individual and regional features make citizens more or less inclined to use this new transportation mode. Overall, our work provides insights that advance the understanding, development, and commercialisation of AAM transportation systems and, thus, can help firms and policymakers to boost its demand.

First, our findings on the effects of individual features may guide information campaigns for attracting AAM users. For instance, our work suggests that these campaigns should target specific groups of people, such as frequent flyers and youngsters, whom we find keen on using AAM. Furthermore, we observe that prior experience with (small) drones positively affects citizens' attitudes toward AAM. This speaks in favour of establishing experimental spaces (*e.g.*, test beds and living labs) where citizens can try out drones, thus nurturing their willingness to use AAM (Engels et al., 2019).

Second, results on regional features are highly interesting. The negative effects of *Public transportation* and *Share of innovators* encourage policymakers to be careful in integrating AAM into the extant regional public transportation system and industrial fabrics. To this end, public R&D investments targeted directly at AAM might be of great help, given the high level of uncertainty which still surrounds its development and social acceptance. Furthermore, results on regional features call for further research. For instance, future studies may further explore the negative association we found between the willingness to use AAM and the level of innovativeness, testing its robustness and assessing the underlying mechanisms.

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Appendix 1

Sample respondents closely match the Italian population with respect to age, gender, geographic area and region of residency, as reported in Table A1.

[Table A1 about here]

Appendix 2

[Table A2 about here]

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Tables

Table 1. Descriptive statistics and correlation matrix

		Mean	Std.Dev.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1)	Willingness to use AAM	.978	.886	1													
(2)	Female	.505	.5	-0.0782*	1												
(3)	ln(age)	3.84	.331	-0.2524*	-0.0354	1											
(4)	Graduate	.487	.5	0.1295*	-0.0305	-0.2036*	1										
(5)	Non-Executive	.389	.488	0.0473	-0.0617	-0.1571*	0.0133	1									
(6)	Executive	.243	.429	0.1787*	0.0193	-0.0633*	0.2027*	-0.4527*	1								
(7)	Prior drone experience	.234	.424	0.2255*	-0.0107	-0.1714*	0.0946*	0.0199	0.1671*	1							
(8)	Moderate flyer	.567	.496	-0.0148	0.0055	-0.0446	0.0006	0.0317	-0.0744*	-0.0181	1						
(9)	Frequent flyer	.222	.416	0.1858*	0.0371	-0.0997*	0.1720*	0.0039	0.2532*	0.1494*	-0.6121*	1					
(10)	Known drone applications	3.55	1.98	0.0646*	-0.0933*	0.0920*	0.0395	-0.0904*	0.0172	0.0339	-0.0719*	0.1377*	1				
(11)	R&D share of GDP	1.36	.423	-0.0246	-0.0755*	0.0909*	-0.0587	0.0194	-0.0606	-0.0161	0.0196	-0.0692*	0.1059*	1			
(12)	Share of innovators	47.9	5.72	-0.0794*	-0.0367	0.0729*	-0.0776*	0.0034	-0.0252	-0.0194	0.0094	-0.0510	0.0280	0.4408*	1		
(13)	Public transportation	3.04	.229	-0.0166	0.0558	0.0157	0.0048	-0.0464	0.0543	0.0067	-0.0035	-0.0211	0.0593	0.2499*	0.0445	1	
(14)	CO2 emissions	4.37	.621	-0.0523	0.0720*	0.0162	-0.0289	-0.0215	0.0099	-0.0073	-0.0178	0.0377	0.0130	0.3389*	0.5613*	0.4281*	1

Note: * indicates correlation coefficients significant at the 5% level. The variable *willingness to use AAM* takes value 0 for ‘No’, 1 for ‘Necessity’, and 2 for ‘Yes’.

Table 2. Multinomial logit model

		Necessity vs No	Yes vs No
Individual	Female	-0.147	-0.427***
		(0.157)	(0.149)
	ln(age)	-0.813***	-1.473***
		(0.262)	(0.172)
	Graduate	-0.140	0.0656
		(0.204)	(0.204)
	Non-Executive	0.166	0.459**
		(0.306)	(0.200)
	Executive	0.236	0.891***
		(0.254)	(0.197)
	Moderate flyer	0.410**	0.445*
		(0.195)	(0.227)
	Frequent flyer	0.646**	0.949***
		(0.297)	(0.296)
	Known drone applications	0.0580	0.0855*
		(0.0471)	(0.0487)
	Prior drone experience	0.331	0.840***
		(0.233)	(0.261)
Regional	R&D share of GDP	-0.0172	0.116
		(0.181)	(0.158)
	Share of innovators	-0.0581*	-0.133***
		(0.0299)	(0.0281)
	Public transportation	-0.648**	-1.220***
		(0.326)	(0.426)
	CO2 emissions	0.291*	0.352*
		(0.173)	(0.201)
	Controls	✓	✓
	Constant	4.666**	12.73***
		(1.869)	(1.510)
	Observations	1,007	
	Regions	20	
	Log-likelihood	-972.2	
	Pseudo R-squared	0.0932	

Note: Robust standard errors in parentheses clustered at the regional level. *** p-value (p) <0.01, ** p<0.05, * p<0.1. ‘No’ is the chosen baseline category. Coefficients for control variables (‘Controls’) are available upon request.

Table 3: Average Marginal Effects, for selected variables

		No	Necessity	Yes
Individual	Female	0.0644***	0.00938	-0.0737**
		(0.0191)	(0.0308)	(0.0344)
	ln(age)	0.249***	-0.0186	-0.230***
		(0.0358)	(0.0408)	(0.0325)
	Graduate	0.00430	-0.0285	0.0242
		(0.0310)	(0.0367)	(0.0431)
	Non-Executive	-0.0699	-0.00873	0.0786***
		(0.0464)	(0.0410)	(0.0281)
	Executive	-0.128***	-0.0313	0.160***
		(0.0379)	(0.0380)	(0.0345)
	Moderate flyer	-0.0895***	0.0329	0.0565
		(0.0330)	(0.0353)	(0.0465)
	Frequent flyer	-0.171***	0.0323	0.139**
		(0.0475)	(0.0501)	(0.0583)
	Known drone applications	-0.0154**	0.00287	0.0125
		(0.00705)	(0.00897)	(0.0108)
	Prior drone experience	-0.130***	-0.0114	0.142***
		(0.0467)	(0.0288)	(0.0410)
Regional	R&D share of GDP	-1.251	-1.202	2.452
		(2.335)	(3.349)	(3.574)
	Share of innovators	0.0212***	0.000896	-0.0221***
		(0.00359)	(0.00592)	(0.00655)
	Public transportation	0.204***	-0.0111	-0.193**
		(0.0627)	(0.0602)	(0.0869)
	CO_2 emissions	-0.0678**	0.0204	0.0474
		(0.0323)	(0.0281)	(0.0385)

Note: *** p-value (p) <0.01, ** p<0.05, * p<0.1.

Appendix 1

Table A2. Distribution of demographic variables, sample vs Italian population

	Share	
	Sample	Italy
Gender		
Male	49.45	49.51
Female	50.55	50.49
Age		
18-24	7.05	9.57
25-34	15.29	14.63
35-44	19.86	17.48
45-54	20.16	22.19
55-64	20.95	19.99
65-74	16.68	16.13
Geographic area		
North	46.97	46.16
Centre	19.86	19.86
South & Island	33.17	33.99
Region		
Abruzzo	2.38	2.17
Basilicata	0.7	0.94
Calabria	2.68	3.16
Campania	10.82	9.6
Emilia-Romagna	6.55	7.44
Friuli-Venezia Giulia	2.58	2.01
Lazio	9.93	9.74
Liguria	2.48	2.51
Lombardia	18.97	16.81
Marche	2.88	2.5
Molise	0.5	0.5
Piemonte	7.55	7.15
Puglia	6.26	6.69
Sardegna	2.48	2.75
Sicilia	7.35	8.18
Toscana	5.96	6.18
Trentino-Alto Adige	0.79	1.79
Umbria	1.09	1.44
Valle d'Aosta	0.2	0.21
Veneto	7.85	8.23

Note: Population data come from the Italian Census (2021)

Appendix 2

Table A2. Robustness check for Table 2, Generalised structural equation model

		Necessity vs No	Yes vs No
Individual	Female	-0.147	-0.427***
		(0.176)	(0.161)
	ln(age)	-0.813***	-1.473***
		(0.282)	(0.255)
	Graduate	-0.140	0.0656
		(0.184)	(0.166)
	Non-Executive	0.166	0.459**
		(0.202)	(0.190)
	Executive	0.236	0.891***
		(0.255)	(0.226)
	Moderate flyer	0.410*	0.445**
		(0.221)	(0.210)
	Frequent flyer	0.646**	0.949***
		(0.296)	(0.265)
	Known drone applications	0.0580	0.0855**
		(0.0458)	(0.0416)
	Prior drone experience	0.331	0.840***
		(0.230)	(0.195)
Regional	R&D share of GDP	-0.0172	0.116
		(0.315)	(0.278)
	Share of innovators	-0.0581	-0.133***
		(0.0432)	(0.0399)
	Public transportation	-0.648	-1.220**
		(0.639)	(0.588)
	CO2 emissions	0.291	0.352
		(0.252)	(0.226)
	Controls	✓	✓
	Constant	4.666	12.73***
		(2.948)	(2.731)
	Observations	1,007	1,007
	Regions	20	20
	Log-likelihood	-972.2	-972.2

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1